Space Environment

Announcement of Opportunity for the
Radiation Belt Storm Probes
and Geospace-Related Missions of Opportunity

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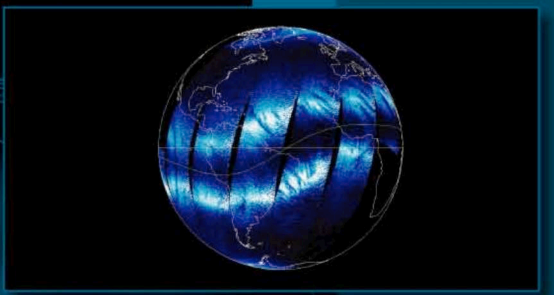
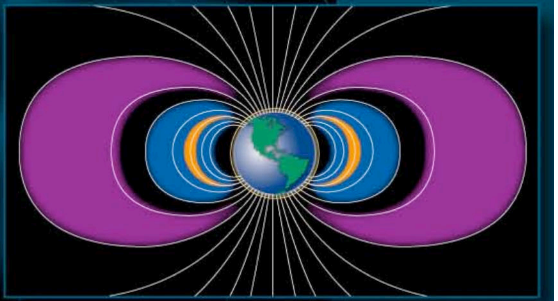
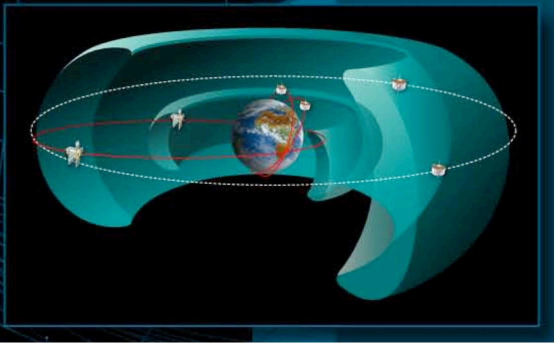
Radiation Effects and Analysis







Radiation Belt Storm Probes Orbit

- **Orbit Parameters (Section 1.1)**
  - **Perigee altitude – approximately 500 km**
  - **Apogee altitude – approximately 30,600 km**
  - **Inclination – no greater than 18 degrees**
  - **Launch – 2011**
  - **Prime mission duration – 2 years**
- **Radiation Belt Storm Probes (RBSPs) will be exposed to a challenging radiation environment which will cause a broad range of effects on instruments and spacecraft systems**
  - **Total ionizing dose**
  - **Displacement damage dose**
  - **Non-destructive single event effects**
  - **Destructive single event effects**
  - **Surface charging**
  - **Internal, deep-dielectric charging/discharging**

Consequences of Space Environment Effects

- **Loss of data**
  - **Corruption of data in memory storage**
  - **Interruption of data transmission**
- **Performance degradation**
  - **Reduced microelectronics functionality**
  - **Degraded sensors**
- **Interference on instruments**
  - **Noise on sensors**
  - **Biasing of instrument readings**
- **Service outages**
  - **System resets, spacecraft safeholds**
- **Shortened mission lifetime**
  - **Microelectronics degradation**
  - **Sensor degradation**
- **Loss of instrument, sub-system or entire spacecraft**
  - **Permanent damage on microelectronics**
  - **Failure of sensors**

Radiation Environment Levels

Category	Examples
Low: • < 10 krads-si with ~100 mils AL shielding • Moderate single event effects environment • Low displacement damage environment	• Low altitude/low inclination (Hubble, Shuttle) • Short mission duration
Moderate: • 10-100 krads-si with ~100 mils AL shielding • Intense single event environment • Moderate displacement damage environment	• Low altitude/high inclination (Earth Observing) • L1, L2, Geostationary • Medium mission duration
High: • >100 krads-si with ~100 mils AL shielding • Intense single event effects environment • Intense displacement damage environment	• Europa • Geostationary Transfer Orbit, Medium Earth Orbit • << 1 AU • Long mission duration

- ***Radiation Belt Storm Probes are in the HIGH Category***

Examples of Single Event Effects (SEEs)

Name of SEE	*Example of Problem*	*Examples of Affected Components*
Single Event Upset (SEU)	**Corruption of the information stored in a bit**	**Memory cell, latches**
Multiple Event Upset (MEU)	**Several bits corrupted by a single particle**	**Memories**
Single Event Functional Interrupt (SEFI)	**Loss of normal operation**	**Complex devices with built-in state machine/control sections**
Single Event Transient (SET)	**Transient glitch**	**Analog and digital circuits, photonics**
Single Event Latchup (SEL)	**High current condition**	**Complementary Metal Oxide Semiconductor Technology (CMOS), Bipolar CMOS circuits**
Single Event Burnout (SEB)	**High current condition**	**Bipolar Junction Transistor, Power Metal Oxide Semiconductor Field Effect Transistors**
Single Hard Error (SHE)	**Stuck bit**	**Memories**
Single Event Gate Rupture (SEGR)	**Rupture of gate dielectric**	**Power Metal Oxide Semiconductor Field Effect Transistors, flash Programmable Read-Only Memory**

Special Considerations: Space Environment

Section 5.2.2 - Candidate Instruments for the Radiation Belt Storm Probes Payload

- The RBSP orbit presents significant environment hazards for the spacecraft and payload.
- Proposals must provide analysis and a concept for sensors and electronic components, including margin, that demonstrates instrument compatibility and robustness with respect to the mission environment.
- At a minimum, instruments must be designed to preclude permanent damage and mitigate operation outages due to single event effects (SEE) and single event upsets (SEU) related to high energy particles and due to internal and deep dielectric charging.
- Payload providers will be required to verify through design analysis that sensors and electronics components will not incur permanent damage or create discharge hazards that could impact spacecraft or payload health as a result of instrument component internal charging phenomena.

APPENDIX B
GUIDELINES FOR PROPOSAL PREPARATION

D. SCIENCE INVESTIGATION

5. Science Implementation

e. Radiation Environment Effects. This section must address how the instrument design and planned instrument operations addresses the expected radiation environment. The proposal must address planned mitigation of the radiation environment effects and describe how the science goals will be achieved in the expected environment.

Relationship to Evaluation Criteria

- **Scientific Implementation Merit, Including Technical Merit**
  - **Show that the proposed approach to address the mission space environment will assure that the instrument will provide the necessary data to accomplish the investigation**
- **Technical, Management, and Cost (TMC)**
  - **Show that the proposed schedule and costs are reasonable to effectively address the space environment effects**

The Investigation Performance Assurance in the Mission Environment

- **Performance assurance plans include:**
  - **identification of risks in the radiation environment**
  - **methodology that will be used to define the radiation environment**
  - **how radiation requirements will be set including design margins**
  - **methods that will be used assess the radiation sensitivity of components**
  - **approach that will be used to perform a worst case analysis on instrument in order to demonstrate that the design will work in the mission environment under the most stressful operating conditions (data rates, voltages, switching transients, etc.)**
  - **component acceptance criteria**
  - **approach(es) that will be used to mitigate degradation, damage, and interference on instrument**
  - **approach that will be used to assure payload and spacecraft health**